

**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

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Assignee ..... Micron Technology, Inc.  
Group Art Unit ..... 2814  
Examiner ..... Hoa B. Trinh  
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Title ..... Methods of Forming Capacitors

**RULE 312 AMENDMENT AND  
SUBSTANCE OF THE INTERVIEW**

OK TO ENTER: /HBT/

To: Mail Stop Issue Fee  
Commissioner for Patents  
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Responsive to the Notice of Allowance dated September 12, 2007,  
Applicant amends and remarks as follows:

**AMENDMENTS**

## **Amendments to the Claims:**

Please amend the claims as follows:

1. (Currently Amended): A method of forming a capacitor, comprising:

forming a first capacitor electrode over a semiconductor substrate;

forming a capacitor dielectric region onto the first capacitor electrode, the capacitor dielectric region comprising an exposed oxide-containing surface;

treating the exposed oxide-containing surface of the capacitor dielectric region with at least one of a borane or a silane without depositing any layer onto the exposed oxide-containing surface during any of said treating; and

after said treating with at least one of the borane or the silane without depositing any layer onto the exposed oxide-containing surface during any of said treating, then forming a second capacitor electrode over the treated oxide-containing surface, the second capacitor electrode comprising an inner metal surface contacting against the treated oxide-containing ~~surface—the surface, the~~ depositing the second capacitor electrode comprises using a halogen-containing gas, said treating of the exposed oxide-containing surface of the capacitor dielectric region being effective to reduce halogen incorporation into the capacitor dielectric region than would otherwise occur in the absence of said treating.

2. (Original): The method of claim 1 wherein the first capacitor electrode consists essentially of semiconductive material.

3. (Original): The method of claim 1 wherein the first capacitor electrode consists essentially of metal.

4. (Previously Presented): The method of claim 1 wherein the exposed oxide-containing surface comprises hafnium oxide.

5. (Previously Presented): The method of claim 1 wherein the exposed oxide-containing surface comprises aluminum oxide.

6. (Original): The method of claim 1 wherein the treating is with at least one borane.

7. (Original): The method of claim 6 wherein all borane used during the treating is void of halogen.

8. (Original): The method of claim 6 wherein the borane is selected from the group consisting of  $\text{BH}_3$ ,  $\text{B}_2\text{H}_6$ ,  $\text{B}_4\text{H}_{10}$ ,  $\text{B}_5\text{H}_9$ ,  $\text{B}_6\text{H}_{10}$  and  $\text{B}_{10}\text{H}_{14}$ , and mixtures thereof.

9. (Original): The method of claim 1 wherein the treating is with at least one silane.

10. (Original): The method of claim 9 wherein all silane used during the treating is void of halogen.

11. (Original): The method of claim 9 wherein the silane is selected from the group consisting of  $\text{SiH}_4$ ,  $\text{Si}_2\text{H}_6$ ,  $\text{Si}_3\text{H}_8$  and  $\text{Si}_4\text{H}_{10}$ , and mixtures thereof.

Claims 12-15 (Canceled).

16. (Original): The method of claim 1 wherein the treating comprises a temperature from  $200^\circ\text{C}$  to  $500^\circ\text{C}$ , and a pressure from 1 Torr to 100 Torr.

17. (Original): The method of claim 1 wherein the treating is for at least 1 second.

18. (Original): The method of claim 1 wherein the treating is for at least 10 seconds.

19. (Original): The method of claim 1 wherein the inner metal surface comprises an elemental metal or an alloy of elemental metals.

20. (Original): The method of claim 19 wherein the inner metal surface comprises tungsten.

21. (Original): The method of claim 1 wherein the inner metal surface comprises a conductive metal compound.

22. (Original): The method of claim 21 wherein the inner metal surface comprises TiN.

23. (Original): The method of claim 1 wherein the second capacitor electrode consists essentially of metal.

24. (Previously Presented): The method of claim 1 comprising conducting the treating to be effective to reduce leakage current of the capacitor than would otherwise occur in the absence of said treating.

25. (Previously Presented): The method of claim 1 wherein the exposed oxide-containing surface comprises OH groups, the treating being effective to passivate said OH groups.

Claims 26-31 (Canceled).

32. (Original): The method of claim 1 wherein the first capacitor electrode consists essentially of semiconductive material and the second capacitor electrode consists essentially of metal thereby forming an MIS capacitor.

33. (Original): The method of claim 1 wherein the first capacitor electrode consists essentially of metal and the second capacitor electrode consists essentially of metal thereby forming an MIM capacitor.

34. (Previously Presented): A method of forming a capacitor, comprising:

forming a first capacitor electrode over a semiconductor substrate;  
forming a capacitor dielectric region onto the first capacitor electrode, the capacitor dielectric region comprising an exposed oxide-containing surface;

treating the exposed oxide-containing surface of the capacitor dielectric region with at least one of a borane or a silane at a temperature from 200°C to 500°C and a pressure from 1 Torr to 100 Torr for at least 1 second, the treating being void of depositing any layer onto the exposed oxide-containing surface during any of said treating; and

after said treating with at least one of the borane or the silane which is void of depositing any layer onto the exposed oxide-containing surface during any of said treating, then forming a second capacitor electrode consisting essentially of metal over the treated oxide-containing surface, the second capacitor electrode comprising an inner metal surface contacting against the treated oxide-containing surface—the surface, the depositing the second capacitor electrode comprises using a halogen-containing gas, said treating of the exposed oxide-containing surface of the capacitor dielectric region being effective to reduce halogen incorporation into the capacitor dielectric region than would otherwise occur in the absence of said treating.

35. (Previously Presented): The method of claim 34 wherein the exposed oxide-containing surface comprises hafnium oxide.

36. (Previously Presented): The method of claim 34 wherein the exposed oxide-containing surface comprises aluminum oxide.

37. (Original): The method of claim 34 wherein the treating is with at least one borane.

38. (Original): The method of claim 37 wherein all borane used during the treating is void of halogen.

39. (Original): The method of claim 37 wherein the borane is selected from the group consisting of  $\text{BH}_3$ ,  $\text{B}_2\text{H}_6$ ,  $\text{B}_4\text{H}_{10}$ ,  $\text{B}_5\text{H}_9$ ,  $\text{B}_6\text{H}_{10}$  and  $\text{B}_{10}\text{H}_{14}$ , and mixtures thereof.

40. (Original): The method of claim 34 wherein the treating is with at least one silane.

41. (Original): The method of claim 40 wherein all silane used during the treating is void of halogen.



42. (Original): The method of claim 40 wherein the silane is selected from the group consisting of  $\text{SiH}_4$ ,  $\text{Si}_2\text{H}_6$ ,  $\text{Si}_3\text{H}_8$  and  $\text{Si}_4\text{H}_{10}$ , and mixtures thereof.

Claim 43 (Canceled).

44. (Original): The method of claim 34 wherein the treating is for at least 10 seconds.

45. (Original): The method of claim 34 wherein the inner metal surface comprises an elemental metal or an alloy of elemental metals.

46. (Original): The method of claim 45 wherein the inner metal surface comprises tungsten.

47. (Original): The method of claim 34 wherein the inner metal surface comprises a conductive metal compound.

48. (Original): The method of claim 47 wherein the inner metal surface comprises TiN.

49. (Original): The method of claim 34 wherein the treating is effective to reduce leakage current of the capacitor than would otherwise occur in the absence of said treating.

50. (Previously Presented): The method of claim 34 wherein the exposed oxide-containing surface comprises OH groups, the treating being effective to passivate said OH groups.

51. (Previously Presented): The method of claim 34 wherein the depositing the second capacitor electrode comprises using a halogen-containing gas, the treating being effective to reduce halogen incorporation into the capacitor dielectric region than would otherwise occur in the absence of said treating.

Claims 52-124 (Canceled).

125. (Previously Presented): The method of claim 1 wherein the treating is with at least one borane and with at least one silane.

126. (Previously Presented): The method of claim 34 wherein the treating is with at least one borane and with at least one silane.

Claims 127 and 128 (Canceled).

129. (Previously Presented): A method of forming a capacitor, comprising:

forming a first capacitor electrode over a semiconductor substrate;

forming a capacitor dielectric region onto the first capacitor electrode, the capacitor dielectric region comprising an exposed oxide-containing surface;

treating the exposed oxide-containing surface of the capacitor dielectric region with at least one borane and with at least one silane; and

forming a second capacitor electrode over the treated oxide-containing surface, the second capacitor electrode comprising an inner metal surface contacting against the treated oxide-containing ~~surface~~ the surface, the depositing the second capacitor electrode comprises using a halogen-containing gas, said treating of the exposed oxide-containing surface of the capacitor dielectric region being effective to reduce halogen incorporation into the capacitor dielectric region than would otherwise occur in the absence of said treating.

## REMARKS

Claims 1, 34 and 129 are amended. Claims 1-11, 16-25, 32-42, 44-51, 125, 126, and 129 are in the application.

The independent claims are amended herein to insert a comma for improved readability in the claims. No change in scope occurs thereby.

This filing also constitutes Applicant's statement of the substance of the Interview conducted on August 28, 2007. In the interview, the Examiner indicated that she found claims 1, 34, and 129 allowable only if the subject matter of claim 26 was included therein. Applicant agreed to such in order to obtain allowance, and without any admission or agreement to the propriety of the Examiner's rejection or requirement that claims 1, 34 and 129 were allowable only if the stated language was added. During the interview, the undersigned further agreed to the cancellation of claim 26.

The above amendments to include commas could not have been made earlier, as the Examiner's amendment which did not have the commas was just received. Accordingly, it is appropriate to enter this amendment at this time.

Respectfully submitted,

Dated: 10-10-07

By: 

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